

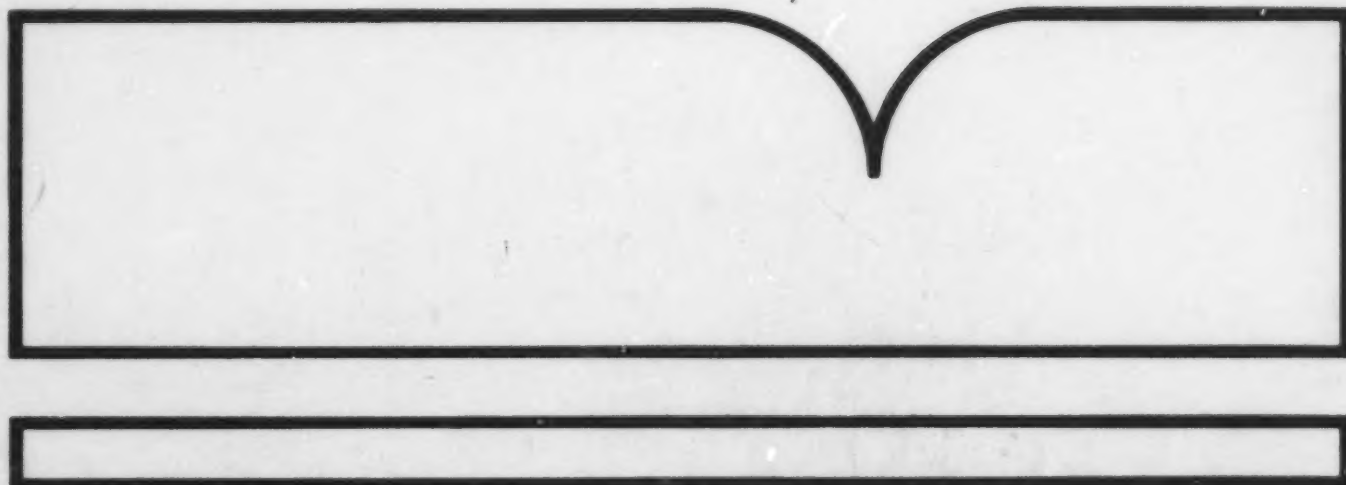
Epidemiological Studies of Otitis Externa  
Report of a Prospective and of a Retrospective  
Study of Otitis Externa Among Swimmers

Yale Univ.  
New Haven, CT

Prepared for

Health Effects Research Lab.  
Cincinnati, OH

May 81



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# EPIDEMIOLOGICAL STUDIES OF OTITIS EXTERNA

Report of a prospective and of a retrospective  
study of otitis externa among swimmers

by

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## FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. In Cincinnati, the Environmental Research Center possesses this multi-disciplinary focus through programs engaged in

- o studies on the effects of environmental contaminants on man and the biosphere, and
- o a search for ways to prevent contamination and to recycle valuable resources.

The Health Effects Research Laboratory conducts studies to identify environmental contaminants singly or in combination, discern their relationships, and to detect, define, and quantify their health and economic effects utilizing appropriate clinical, epidemiological, toxicological, and socioeconomic assessment methodologies.

This report describes the results of epidemiological surveys to establish relationships between Otitis Externa and the bacterial flora of bathing waters and the value of bacterial indicators of the sanitary quality of bathing waters as risk assessment entities. This study indicated statistically positive associations between Otitis Externa and air and water temperatures, age, swimming and length of time swimming. No relationships were established between Otitis Externa and bacterial indicators of bathing water quality or between otic abnormal flora and bacterial indicators of water quality.

James B. Lucas  
Acting Director  
Health Effects Research Laboratory

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## ABSTRACT

In conjunction with the United States Environmental Protection Agency's ongoing evaluation of health effects associated with recreational water, three epidemiological studies on otitis externa (swimmer's ear) were conducted. This report contains the results of the last two studies.

A prospective study (Study II) conducted in New Orleans from June 1979 to August 1979 compared boy scouts at one camp that swam in a fresh water lake with boy scouts at another camp that swam in a chlorinated swimming pool. In this study, 3 percent of the boy scouts reported ear complaints in the week following camp, but none had otitis externa confirmed by a physician. A higher relative humidity at the camp where boy scouts swam in a chlorinated pool was associated with a greater degree of abnormal flora (Gram-negative bacteria and *Staphylococcus aureus*) colonization of the ear. There was no association of abnormal flora colonization with bacterial water indices *Pseudomonas aeruginosa*, *Escherichia coli* or enterococci.

A retrospective study (Study III) was completed by the Department of Public Health and Epidemiology, School of Medicine, Yale University from July 1980 to September 1980. Data from 29 cases and 29 controls matched by age and sex were collected. Ambient air temperature, warm water temperature, less than 18 years of age, being female, swimming and length of time spent swimming were associated positively with cases of otitis externa.

An evaluation of all three epidemiological studies done to date yield the following possible risk factors associated positively with otitis externa; less than 18 years of age, being female, length of time spent swimming, high humidity, high ambient air temperature and warm recreational water. Water quality as measured by fecal coliforms, enterococci and *Pseudomonas aeruginosa* was not found to be associated with otitis externa.

This report was submitted in fulfillment of Contract No. RFQ-80-234 by the Department of Public Health and Epidemiology, School of Medicine, Yale University under the sponsorship of the U.S. Environmental Protection Agency.

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## ACKNOWLEDGEMENTS

Many persons gave freely of their time and effort in cooperating with the investigators in the conduct of these studies. We are thankful for their participation and we are indebted to each of them. However, special recognition is given to the following physicians who are on the staff of the Yale University Health Services, Dr. Merrill A. Baratz, Associate Clinical Professor of Pediatrics, Dr. John W. Blanton, Jr., Assistant Clinical Professor of Pediatrics, and Dr. John V. Federico, Associate Clinical Professor of Pediatrics and Director, Division of Occupational and Environmental Health Services. Also meriting special acknowledgement is Judith J. Glickstein, R.N., B.S.N., Head Nurse, Pediatric Clinic, Yale University Health Services. These named persons deserve special recognition not only for their active participation in the retrospective study but also for their support and understanding during the entire study.

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## SECTION 1

### INTRODUCTION

In 1921, the Committee on Swimming Pools of the American Public Health Association surveyed physicians and health officers to determine diseases spread by bathing waters. Among the major diseases listed by them was otitis externa or, as it is more commonly known, "swimmers ear."

Otitis externa is an inflammation of the outer ear canal, characterized by pain, swelling, drainage and occasionally fever. Tremble (1952) reported that 40% of all otological cases were outer ear related. A more recent survey (Price, 1976) cited that in children there are five cases of otitis externa for every one case of otitis media.

During World War II, interest in otitis externa grew as an appreciable number of American and British soldiers fighting in the Mediterranean and South Pacific suffered from this disease. It was given a morbidity of 8% to 80% (Nelson, 1945; Syverton et al., 1946) and was claimed as the second greatest cause of time lost from duty (Gordon, 1948).

These cases, occurring among the troops during World War II, were thought to be due to the hot and humid weather (Senturia, 1945). As interest grew some believed otitis externa was due to the lowering of the pH of the sebaceous glands of ears and hence removal of the surface lipids (Tremble and Baxter, 1952). Others believed the cause was a complex of high humidity, high air temperature, trauma and loss of surface lipids (Senturia and Carruthers, 1954).

Detailed research identified the pathology of this disease (Senturia, et al, 1955; Sophian and Senturia, 1955), and lead to the development of an animal model, the cat. Using this model, high temperatures and high relative humidities were not found to be sole factors responsible for otitis externa nor had they any effect on the prolonged survival of implanted organisms. In addition, trauma to the skin of the cat's external auditory canal and removal of surface lipids had no effect on the disease process (Senturia and Carr, 1958).

The association between otitis externa and swimming was noted as far back as 1895 in some medical textbooks (Adams, 1951). However, the role of swimming as a causative factor of otitis externa was overshadowed by theories of high temperature, high relative humidity, the condition of the sebaceous glands, trauma and the presence of surface lipids. Nevertheless, swimming still was mentioned as a factor, but its contribution was never researched (Adams, 1951, Hostelley, 1951; Tremble and Baxter, 1952; Senturia

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Since hot and humid weather were thought to be major cause of otitis externa, various yeasts and fungi were claimed as the major infective agents (Conley, 1948). Studies by Alonso (1951) and Branca (1953) found that less than 20% of the cases investigated actually were caused by a fungus. Most cases of otitis externa were found to be of bacterial origin. The organism isolated most frequently varied from study to study. Alonso (1951), McLaurin (1954) and McDowall (1974) found that the genus Staphylococcus was the primary organism isolated from cases of otitis externa. Singer et al, (1952), Hardy et al, (1954), Way et al, (1955), and Saunders and Ray (1965) found that the majority of organisms were Pseudomonas aeruginosa and various other gram negative bacteria. When it was observed that P. aeruginosa was resistant relatively to many disinfectants (Favero, 1965; Cothran, 1962) and hence a common contaminant of poorly disinfected swimming pools, attention was focused on this organism as the major cause of otitis externa. Subsequent studies had noted that P. aeruginosa was a common inhabitant of organically enriched fresh and salt waters (Hoadley et al. 1968, Cabelli et al, 1976). These reports lead to the theory that most cases of otitis externa were the results of people swimming in water containing high levels of P. aeruginosa.

In 1975, Hoadley and Knight reported that otitis externa was associated significantly with swimming and that P. aeruginosa was the major etiological agent. However, the study did not utilize a comparison or control group, nor did it assess the quality of recreational waters involved.

Weingarten (1977) reported on a retrospective study concerning an outbreak of otitis externa in a swimming pool at a housing development. Over one third of the swimmers were treated by physicians for otitis externa, but only nine swabs of the ear canals were taken from these cases. All cases revealed the presence of P. aeruginosa either as the only bacteria or mixed with other organisms. Typing was not done to confirm that the P. aeruginosa isolated from the ears were of the same phage or serotype as those organisms which were isolated from the swimming pool water nor was any information obtained on the sanitary quality of water in the swimming pool water prior to and during the outbreak.

In an effort to correlate the incidence of P. aeruginosa in water with the incidence of otitis externa, Seyfried and Fraser (1978) demonstrated that indeed the serotypes and phage types isolated from swimming pool waters were the same as those isolated from cases of otitis externa. However, adequate controls were not utilized in this study and P. aeruginosa was assessed as a causative agent (cases were deleted when the culture was negative for P. aeruginosa).

All of these studies tended to point indirectly to a correlation between swimming and the incidence of otitis externa. As part of the United States Environmental Protection Agency's studies on recreation water quality and indicators of water quality, a series of studies were conducted to determine if there was a direct relationship between the incidence of otitis

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externa, swimming and the quality of the recreational water, (Cabelli, 1980). If such a relationship exists, what is the indicator of choice and what, if any, should be the standard or guideline?

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The first of these studies (Study I), a prospective study, was conducted during the summer of 1977 (Resnick, Levin and Cabelli, 1981), and involved swimming pools and fresh water ponds in the state of Rhode Island. The ears of subjects were cultured prior to swimming and after swimming. Subjects were contacted one week later to obtain data concerning possible ear infections. No confirmed cases of otitis externa were found from the 2,155 subjects examined. Significant differences were seen in the type of ear flora found in swimmers and non-swimmers. More swimmers than non-swimmers had abnormal flora (Gram negative bacteria and S. aureus were considered abnormal flora). Acinetobacter species and P. aeruginosa were isolated in 58.8% and 11.9% respectively, of those exhibiting abnormal flora. With the exception of fecal streptococci, there was no relationship between abnormal flora and bacterial indicators of sanitary quality. In the case of fecal streptococci, there was a slight positive relationship. Although there was no confirmed case of otitis externa, ear complaints were recorded and there appeared to be a slight correlation with swimming, abnormal flora, high humidity and individuals less than 20 years of age.

For Study II, also a prospective study, a decision was made to maximize the probable risk factors identified in Study I in anticipation that a clearer picture of the epidemiology of otitis externa could be obtained. A target population of children and adolescents under 20 years of age was desired. An area with a warm climate and high humidity was preferred, also. An ideal study site would have the following characteristics: it would have a large stable population of swimmers that could be observed for a definite time period; the swimming water should have relatively high counts of P. aeruginosa and the water should not be subject to pollution by sewage. The study design and results are summarized in Section 3.

Based upon the results of Study II, a third study (Study III) was undertaken by Yale University School of Medicine, Department of Epidemiology and Public Health. A case-control study was designed and implemented. The results are presented in Section 4. While the picture is yet incomplete, the results of these two studies provide some basic information about the risk factors involved and give insight into the type of recreational water involved. Also data are presented concerning bacterial indicators of water quality which seem to be related to the incidence of otitis externa in swimmers.

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### CONCLUSIONS

This report presents the results of two epidemiological studies on otitis externa. These two studies and another study reported previously give some insight into the epidemiology of otitis externa. While the whole picture is not yet complete, major parts of the epidemiology of this disease have been identified.

From the findings presented herewith, the following conclusions are formulated:

1. Otitis externa appears to be a disease associated with people under 18 years of age. Adult otitis externa does occur but was not found in these studies. Further work may be needed concerning the occurrence of otitis externa in adult populations. The higher incidence of otitis externa in females rather than males while significant in this report needs to be investigated further.
2. Hot and humid air appears to be associated with otitis externa. This association may be indirect rather than direct. Hot and humid air may affect a person's swimming habits during such periods of extreme weather. The interaction between swimming and hot and humid air should be researched further.
3. Swimming appears to be associated with otitis externa but, more importantly, seems to be associated with the amount of time spent actually swimming. The time spent swimming should be considered in future studies of otitis externa.
4. Otitis externa does not appear to be associated with bacterial indicators of recreational water quality such as fecal coliforms, enterococci or P. aeruginosa. This suggests that bacterial indices involving these organisms as measures of recreational water quality may be of little use in evaluating the potential risk to swimmers who bathe in these waters to acquire otitis externa.
5. While P. aeruginosa may be the most commonly isolated organism from cases of otitis externa, the role of other organisms as etiological agents (Acinetobacter, Klebsiella, Enterobacter and Staphylococcus) should not be excluded when studying otitis externa.

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## PROSPECTIVE STUDY OF OTITIS EXTERNA (STUDY II - NEW ORLEANS STUDY)

### Methodology and Results

In the summer of 1979, the second of three studies on otitis externa began. Based on the 1977 study, it was decided that Boy Scout camps would be used in this study, Study II. The ages at which boys went to scout camp (7 to 18 years) had been identified as high risk ages (Resnick, Levin, and Cabelli, 1981). Generally, most or all boys spend a great deal of time while at camp swimming. In addition, campers may be followed closely for at least one week to ascertain subsequent cases of otitis externa as they may occur. The southern United States was chosen since the ambient air temperatures and relative humidities tend to be uniformly high and hence variation in these factors usually is slight and should have little effect on the fluctuation of cases thereby eliminating these factors as confounding variables. Also, it had been reported that high temperatures tend to support high densities of P. aeruginosa in recreational waters (Hoadley, 1968).

The year prior to the study was spent visiting various Boy Scout camps in the southern United States. Sites for visitation were selected by using the following criteria:

- 1) approximately 800 or more campers enroll in the camp during the summer;
- 2) swimming is a major part of the camp's activities;
- 3) swimming occurs in a body of water with high densities of P. aeruginosa; and
- 4) the water is not contaminated by known sources of pollution.

Two camp sites in the New Orleans Area Boy Scout Council were chosen, using the above criteria. The first, Salmen Reservation, was in a wilderness area around a man-made lake. Samples taken during August, 1978, showed that the lake had high concentrations of P. aeruginosa. The second, Camp Salmen, was a well established "conventional" camp which had a chlorinated swimming pool. This selection seemed to be ideal as it would afford two types of recreational water, two levels of P. aeruginosa and two comparable study groups to be analyzed for the incidence of otitis externa.

### Materials and Methods

Sites: Salmen Reservation is a wilderness area in Mississippi.

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The 83 acre lake is man-made, formed by the damming of a spring fed river. There were no known sources of pollution affecting the bacterial quality of the lake. The study was conducted there for three weeks starting on June 10 and running until June 30, 1979. The second site, Camp Salmen, is a well established camp situated along a bayou off Lake Pontchartrain. The camp swimming pool was located centrally and water in the swimming pool came from the camp's drinking water supply. The swimming pool water was chlorinated manually every night by adding granulated calcium hypochlorite. The swimming pool was "L" shaped with the water flowing from the shallow to the deep end. This study was conducted between July 9 and August 3, 1979 and covered four camp sessions. The first week at Camp Salmen was eliminated from the study since campers were sent home at mid-week after a hurricane.

Water Analyses: Samples of water for laboratory analyses were collected from both sites during camper swimming activities. The lake was sampled once a day during the middle of a two hour swim period. These samples were collected in the region of the lake where the campers swam and where the water depth was three feet (3'-0"). The swimming pool water was sampled twice a day. One sample was collected during the morning swim period and the other sample was collected during the afternoon swim period. The water samples taken from the swimming pool were mixtures of waters from the three feet and six feet depth areas. All samples were processed in the laboratory within 15 minutes of collection.

All samples were examined for Escherichia coli, enterocci, and P. aeruginosa. E. coli were evaluated by the membrane filtration method, mTEC (Dufour, 1975). The filtered cultures were resuscitated at room temperature for two hours and then incubated in a water bath at 44°C for 18 to 22 hours. Enterococci were measured also by the membrane filtration method, mE (Levin and Cabeilli, 1975). After filtration, these cultures were incubated on mE plates at 41.5°C for 44 to 48 hours. Plates with countable colonies then were transferred to esculin iron agar (EIA) media and after 20 minutes at room temperature, colonies positive according to zones of precipitation were counted. The membrane filtration method, mPA (Standard Methods, 1975) was used to determine levels of P. aeruginosa. Water samples of appropriate volume were filtered and then filters were placed on the selective media and incubated at 41.5°C for 44 to 48 hours.

During the camp sessions #6 and #7, an experimental membrane filtration method, mAC, (LaCroix, 1980) was used in an attempt to assess the Acinetobacter levels in the water. After filtration of water samples, filters were placed on mAC media and then these cultures were incubated at room temperature (28-30°C) for 44 to 48 hours. All colonies were counted and plates were then refrigerated. At the end of the week all plates were sent to the Marine Field Station, R.I. along with ear swabs which had been collected. Upon arrival at the laboratory, filters with colonies were immediately transferred to a carbohydrate differential media and incubated at 31°C for two hours. Positive colonies then were marked and the filter was transferred to a pad saturated with oxidase reagent (N. N.N. N-tetramethyl-P phenylenediamine dihydrochloride, 0.1 g/100 ml). Acinetobacter colonies were those which were carbohydrate positive - oxidase negative.

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Water temperature, air temperature and relative humidity were measured daily. At the time when the swimming pool water samples were collected, the free residual chlorine levels and the pH were determined using colorimetric methods.

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**Subjects:** All campers who entered camp at noon on Sunday were enrolled in the study as part of their medical check in. Each camper filled out a questionnaire (see Appendix A) concerning age, race, and previous ear infection experience. To determine the socioeconomic status (SES), campers were asked questions concerning the number of persons in their family and number of rooms, exclusive of the kitchen and bath, in their home. The number of people was divided by the number of rooms to give the SES. A person/room ratio less than one (1.0) was considered a high SES; a ratio between 1.0 and 1.4 was a middle SES; and a ratio greater than 1.4 was considered a low SES. The only persons excluded from the study were those who entered the camp with existing ear problems and those who objected to participation on religious grounds. Upon leaving camp, all campers were given postage paid cards to fill out one week after leaving camp. These cards asked if there were any ear problems after leaving camp. Persons returning cards marked "Yes" were contacted by telephone to determine if they had visited a physician and if so, they were queried about the physician's diagnosis and treatment.

**Ear Microbiology:** Both right and left ears of all campers were cultured on Sunday upon arriving at the camp and on Saturday when the camper checked out. Ears were swabbed by inserting a sterile dry swab from a "Culturette" (Scientific Product, Boston, MA) into the outer ear canal to a depth of approximately five centimeters and rotating the swab gently. The swab was withdrawn and placed back into the sterile holder. The holding media was released by crushing an ampule inside the sterile holder. The cultures were boxed and shipped by air to the Marine Field Station in Rhode Island, within 48 hours of swabbing. Upon arrival, the swabs were streaked first on trypticase blood agar (Scott Labs, Fiskville, R.I.) and then onto MacConkeys agar (DIFCO, Detroit, MI) and incubated for 18 to 24 hours at 35°C. Isolates considered as normal flora were noted as such (e.g. alpha-hemolytic streptococci, corynebacteria, and non-*S. aureus* staphylococci) (Saunders and Ray, 1965). All isolates other than those considered normal flora were characterized fully using either the API system (Analytab Products, Plainview, N.Y.) or according to the Manual of Clinical Microbiology (1975). The results of the ear cultures were classified into three categories as follows:

- 1) Normal flora - both ears had normal flora as described above or one ear had normal flora and the other showed no growth,
- 2) No growth - nothing was recovered from either ear,
- 3) Abnormal flora - isolates cultured from one or both ears that could not be classified as normal flora.

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Data Analysis: All data were coded onto IBM computer cards. Data and tables for statistical analyses were generated with use of a computer statistical package SAS - 76.

### Results

Lake Study: A total of 444 samples were cultured during the three camp sessions at Salmen Reservation. The number of campers at each session was distributed evenly. (See Table 1). The ages ranged from 9 to 18 years with the majority of boys being 11 or 12 years of age. According to the results of the questionnaire, campers were primarily caucasian (97%) and there was a fairly even socio-economic distribution.

The results of the ear cultures are summarized in Table 2. Changes in flora between initial and final cultures varied, however, according to a chi-square analysis there was no statistical significance found for any of these changes. The frequency of abnormal isolates between initial and final cultures was tested using McNemar's test (Colton, 1978). The number of isolates was higher significantly ( $p < .05$ ) among final cultures in some sessions for Enterobacter, Acinetobacter, and Bacillus. (See Table 3). The frequency of isolation for S. aureus was higher among initial cultures for all sessions, especially Session 1.

The microbiological indices of water quality were not excessively high. (See Table 4). The water temperature was relatively constant throughout all sessions at 84°F. The relative humidity and air temperature were relatively steady during each session, but there was a gradual rise in the average air temperature and relative humidity from session to session.

No ear complaints were reported while subjects were at camp and according to mail and telephone follow-up, only 10 out of 444 subjects complained of subsequent earaches. Only one subject visited a physician after camp and that person was diagnosed as having otitis media in conjunction with an upper respiratory infection. The other 9 were not seen by a physician for a confirmed diagnosis.

Swimming Pool Study: The demographic characteristics of the Camp Salmen campers were similar to those at Salmen Reservation (See Table 5). The majority of the boys were 12 or 13 years of age (22% each), caucasian (82%) and were in the upper socio-economic group (65%). The total population at Camp Salmen was 426 campers and they were distributed evenly over the three sessions.

The changes in ear flora between initial and final cultures are summarized in Table 6. With the swimming pool subjects, there were fewer final cultures classified as "No Growth" (only 1) as compared with lake subjects (53). The frequency of abnormal isolates between initial and final cultures was tested as before using McNemars test. (See Table 7). For most of the individual sessions and the overall total, there were significantly more

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( $p < .05$ ) abnormal isolates in final cultures than initial cultures for Enterobacter, Acinetobacter, P. aeruginosa, other Pseudomonas and Bacillus.

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There was more variation in air temperature and relative humidity during the Camp Salmen sessions than during the Salmen Reservation session. (See Table 8) The water temperature was constant throughout all the sessions at 30°C. In general, the water quality was good as indicated by low E. coli and enterococci counts except during the week of July 23 to 28. (See Table 8) The number of P. aeruginosa and Acinetobacter was abnormally high during that week also. Part of this may be attributed to heavy rains however a brief investigation of the camp water supply showed high Acinetobacter counts. Hence, there was possible water contamination from underground sources.

This possible soil or underground contamination may have been due to a high ground water table and an antiquated pipe system of the camp. This should not have been a problem at the swimming pool since the water in the swimming pool is chlorinated, but the swimming pool water was chlorinated only at night. Often at the time of the morning sample, the residual chlorine had been dissipated by the sun and no free residual chlorine was detected. (See Table 8). Due to the limited microbiological facilities available at the camp, the condition was not investigated further.

Despite the high frequency of abnormal flora, no ear complaints were received at camp and only 14 persons reported as having complaints upon returning home. Again, as with the lake study, none of the respondents visited a physician for a confirmed diagnosis.

Comparison: It was not expected that more abnormal isolates would be recovered from subjects swimming in a chlorinated swimming pool. (See Table 7) than a fresh water lake (See Table 3). To examine this, comparisons of average session relative humidity, air temperature, E. coli counts, enterococci counts and P. aeruginosa counts are summarized in Table 9. The average session air temperature were relatively the same. The bacterial indicators, E. coli and enterococci, were two to ten times higher in the Salmen Reservation lake than in the swimming pool at Camp Salmen. What is noticeably higher at Camp Salmen is the relative humidity and P. aeruginosa counts. According to a student's t-test, the mean relative humidity at Camp Salmen was significantly higher ( $p < .001$ ) than the mean relative humidity at Salmen Reservation. The P. aeruginosa counts were not different significantly between the two camps.

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#### SECTION 4

### A CASE CONTROL STUDY ON OTITIS EXTERNA ( STUDY III - YALE STUDY)

#### Methodology and Results

The inability to collect information on cases of otitis externa in the Rhode Island and the New Orleans studies led to a decision to conduct a retrospective study of the quality of water in which patients with otitis externa had been swimming. It was decided that a more sound epidemiological design was one in which persons with otitis externa would be examined, the swimming exposures determined and the water quality assessed retrospectively. These data would be compared to data collected from other persons selected as controls. Hence, a case-control study was designed with the following objectives.

1. Determine whether or not otitis externa is a disease which is associated with swimming and/or diving, the frequency of diving and/or swimming and the duration of such activities.
2. If it is found that otitis externa is associated with swimming and/or diving, establish the degree of association which may exist between the presence of organisms in the outer ear which seem to be the causative or contributing agents of the infection and the microbiological quality of the water in which the person swam; the microbiological quality being evaluated by the presence of various indicator organisms and/or pathogenic bacteria.
3. If otitis externa is associated with swimming and/or diving, determine if it is associated with marine (saline) waters, fresh waters at natural bathing areas, or with fresh waters in swimming pools.
4. If otitis externa is determined to be associated with the quality of swimming water, develop some of the data needed by the U.S. Environmental Protection Agency and other regulatory bodies, to establish water quality guidelines and/or standards for various types of recreational waters.
5. If otitis externa is determined to be associated with the quality of swimming water, develop data pertaining to risk assessment of this disease and the quality of the water as evaluated by bacterial indices.

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6. If otitis externa is not determined to be associated with swimming and/or diving, assess other risk factors such as humidity, age, race, trauma and sex.

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### Materials and Methods

The Questionnaire: Two questionnaires were developed for this study (See Appendix B). The first was a questionnaire to be filled out by the subject or subject's parent concerning prior swimming episodes and prior ear infections. Questions were designed to assess swimming, average time spent swimming, diving, etc. and the use of earplugs and the wearing of swimming caps. For information on the site of swimming and type of water, the subject completed a simple form and information was verified at the time of the collection of a water sample.

The second questionnaire was designed to be filled out by the attending health professional. Basic demographic data were obtained as well as information concerning symptoms of otitis externa.

Subjects: The subjects were obtained from among subscribers to the Yale Health Plan, a health maintenance organization whose members are primarily faculty, staff, employees and students of Yale University and their families. It was estimated prior to the study that during the average year, the Urgent Visit Clinic, the Pediatric and the Adolescent Clinic would see approximately 100 cases of otitis externa. This study included those clinics as well as the Internal Medicine Clinic so as to not exclude adults from the study group. Due to a technical problem, patients seen at Urgent Visit Clinic were eliminated from the study. A case was included in the study after being diagnosed clinically by a physician as being otitis externa.

A control group was selected from healthy individuals coming to the clinics for routine physical examinations. Controls were matched according to age ( $\pm$  2 years) and sex.

Microbiology of the Ears: Cultures from right and left ears were obtained separately from each case and each control. The cultures were processed according to standard laboratory procedures by the Yale Health Plan medical laboratory. All organisms recognized as potential pathogens were typed according to antibiotic sensitivity for future matching with isolates from the swimming water.

Analyses of Recreational Water: Data were collected concerning the places where cases and controls had been swimming during the prior seven days. If the sites were accessible for collection of a water sample, samples were collected for analyses within 48 hours of the subjects visiting the clinic. Every attempt was made to obtain a minimum of two samples from each swimming pool and from each fresh water site. If the site involved tidal waters, samples were collected for five consecutive days at approximately high tide ( $\pm$  3 hours). All pool samples were collected in bottles containing

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sodium thiosulfate for dechlorination.

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At each site, the air temperature, water temperature, relative humidity and pH of the water were measured and recorded. pH was determined using a portable pH meter (Orion, Cambridge, MA). If the site involved a chlorinated swimming pool, free available residual chlorine and total available residual chlorine levels were determined using the DPD method (Hach Chemical Company, Ames, Ia.).

All sites were analyzed for fecal coliforms, enterococci and P. aeruginosa using membrane filtration methods.

Fecal coliforms were determined by filtering appropriate aliquot portions of the sample. The filter was placed on selective growth media mFC incubated for 24 hours in a 44.5°C water bath. (Standard Methods, 1975). Filters for enterococci enumeration were placed on a selective media mE, (Levin and Cabelli, 1975) and incubated for 44 to 48 hours at 41.5°C. Filters with countable colonies then were placed on an esculin iron agar (EIA) for 20 minutes and positive colonies were counted. P. aeruginosa were measured using a selective media mPA (Standard Methods, 1975). Plates were incubated at 41.5°C for 44 to 48 hours and positive colonies were counted.

During the second week of the study Total Plate Counts (a pour plate method incubated at 35°C for 24 hours) and a membrane filter method for Staphylococcus incubated at 35°C for 24 hours (Standard Methods, 1975) were added to the evaluation of the quality of water in swimming pools.

Data Analysis: All data were coded onto IBM computer cards and analyzed using the pre-programmed statistical package, SAS - 80.

### Results

During the nine week study period from July 7th to September 6th, data on 29 cases and 29 matched controls were collected.

Cases: Based on the physician questionnaire, the symptoms exhibited by cases are summarized in Table 10. The majority of cases exhibited pain (96.6%), swelling (55.1%) and an exudate of some kind (82.7%). The exudate was primarily white or yellow or both (83.3%). More than half (56%) of the cases had an exudate of medium consistency. In most cases there was no evidence of trauma from scratching, picking, etc. The condition of most infections was rated as moderate (92.9%). Most infections were either unilateral, involving only the right ear (41.4%) or bilateral (37.9%).

All the cases came from the Adolescent and Pediatric Clinic so the age of the case ranged from 4 to 17 years of age. (See Figure 1.). The majority (50%) fell into age bracket 6 to 9 years of age. Figure 2 shows that 21 of the cases were female compared to 7 males.

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Similar to the Rhode Island Study, the frequency of cases correlated positively with the average weekly temperature. (See Figure 3). There was

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no association with relative humidity.

Swimming: There was no significant difference between cases and controls associated with: 1) taking a shower or bathing in a tub and 2) a history of past ear infections.

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The proportion of swimmers in cases was found to be significantly higher (at the  $p < .05$  level) than the proportion of swimmers in controls using a chi-square test. (See Table 11)

When comparing only swimmers, the average time spent swimming during a one week period was significantly higher in cases than in controls. (See Table 12). The odds ratio shows that those swimming more than 4 hours a week are 4.8 times more likely to get otitis externa as those that swim less than 4 hours a week. There were no significant differences associated with diving, the wearing of ear plugs or the wearing of a bathing cap.

As to the types of water in which subjects swam the majority of cases and controls swam in swimming pools exclusively, with an even distribution among the other categories. (See Table 13) As to the quality of water, there were no significant differences between cases and controls concerning fecal coliforms, enterococci, *P. aeruginosa*, Staphylococcus or total plate counts. (See Table 14) There were no significant differences found for relative humidity and pH. According to a t-test, the mean water temperature in which cases swam was significantly higher than the mean water temperature in which controls swam ( $p < .05$ ).

Ear Cultures: The results from the ear cultures are summarized in Table 15. The range of organisms isolated was greater in cases and, with the exception of *Pseudomonas stutzeri*, there were no Gram negative isolates from controls. The distribution of Gram positive isolates was similar.

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## SECTION 5

### Discussion

Age: In the Rhode Island Study (Study I), most of the ear complaints were seen in people less than 18 years of age, (Resnick, Levin and Cabelli, 1981). In the Yale Study (Study III), while a population of all ages belonging to the Yale Health Plan were eligible for entrance in to the study, cases came only from persons under 18 years of age (Figure 1). One reason given in the literature for this unique age distribution is the narrowness of the ear canal in children, (Price, 1976). A narrow ear canal does not drain water as easily and is more susceptible to being plugged by swelling or ear wax. Other possible reasons not listed in the literature include immunity and swimming habits. There is some evidence that circulating IgG antibodies specific to *P. aeruginosa* may be found in subjects following otitis externa, (Carr, Sonnenwirth and Senturia, 1967). Perhaps a person becomes immune to organisms causing outer ear infections by the time they reach early adulthood, hence a lower incidence of otitis externa in adult populations. However, in the New Orleans Study (Study II) and the Yale University study (Study III), a history of previous outer ear infections was not associated with ear complaints or cases of otitis externa. This suggests that immunity may have an unimportant role in otitis externa. The evidence of swimming as a factor associated with age is presented in a later section.

Sex: There appears to be no prior data which suggest a sex difference associated with otitis externa. The data collected in the Rhode Island Study did not show any association between sex and ear complaints, (Resnick, Levin and Cabelli, 1981). However, the findings of the Yale Study showed a female to male case ratio of 2.625 to 1.0. One possible reason for this relationship may be that young females have narrower ear canals than young males. However, there is no evidence to support this hypothesis. Another possible explanation is the new social equality of females in the world of sports. In questioning persons with otitis externa, several of the female cases were members of local swimming teams. Perhaps more females than males are now participating in swimming as a sport and hence females are spending more time in the water than males. This increased time in the water may make them more at risk to otitis externa. In the Yale Study there was some evidence to support this theory. Of the females, 90.5% spent more than four hours a week swimming compared to 62.5% of the males. A Fischer's exact test showed this difference in the amount of time spent in the water to be highly significant ( $p < .05$ ) but with such small numbers, it is difficult to make an inference to the population as a whole.

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Humidity and Ambient Air Temperature: The data from Study I and Study II showed no association of otitis externa or ear complaints with high humidity. In Study II at New Orleans, a higher humidity may have been a possible explanation for the higher number of abnormal isolates at Camp Salmen. The frequency of abnormal isolates in Study I and the frequency of otitis externa cases in Study III were associated with ambient air temperature. Data from Study I denoted that the number of subjects with abnormal flora increased as the air temperature increased. In Study II, the number of cases each week increased as the average weekly air temperature increased. (See Figure 3)

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Earlier work with otitis externa correlated high humidities and air temperatures with the incidence of otitis externa, (Senturia, 1945; Branca, 1956). Senturia proposed that prolonged exposure to a hot and humid environment caused the skin of the outer ear canal to absorb water. The absorption of water interfered with the delivery of antimicrobial substances to the surface of the ear canal. In 1958, Senturia and Carr showed that high humidities and high ambient air temperatures do not alter the endogenous flora of the ear canal nor produce any changes in the outer ear canal morphology of their otitis externa cat model. They did find that when the cat's outer ear canals were inoculated with *P. aeruginosa* and other exogenous Gram-negative bacilli, these organisms had a longer survival time in the ear canal at high humidities and air temperatures. A prolonged survival time may account for the higher frequency of abnormal isolates (Study II) and the increase in cases (Study III) during periods of high ambient air temperatures and humidity.

Swimming: The finding of Study I in Rhode Island clearly showed that the number of abnormal isolates and ear complaints was higher in swimmers than non-swimmers. Data from Study III, the Yale Study, indicated that swimming was associated highly with otitis externa. (See Table 11). More importantly however, the findings of Study III showed that the amount of time spent swimming was a very significant factor. Cases spent significantly more time swimming than controls. (See Table 12)

A longer exposure to water while swimming of persons who developed otitis externa may explain the association with high air temperatures and humidities as well as young ages. As the ambient air temperature rises, people, in an effort to escape the heat, tend to spend more time in the water. As for age, the duration of time spent swimming is possibly higher for children than adults. While there appears to be no reports in the literature to support these theories, they seem to be logical assumptions based on informal observations.

Water Quality: The results from Study I indicated a slight positive correlation of outer ear complaints with enterococci counts. However, in the subsequent study in New Orleans (Study II) the number of abnormal isolates or ear complaints did not correlate with any of the bacterial indicators used to measure water quality. (See Table 9).

In Study III, the data showed no significant difference between cases

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and controls when evaluated according to bacterial water quality as measured by fecal coliforms, enterococci, and P. aeruginosa. The same was true for evaluations using total plate counts and staphylococci counts of samples collected from swimming pools. It appears that water quality or, more specifically, the number of organisms to which the outer ear canal is exposed may not be an important factor in otitis externa.

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Earlier work by Shelley and others (1956) indicated that the quantity of bacteria inoculated into an outer ear canal had no effect on the survival of the bacteria nor the ability of the bacteria to cause infection.

Of particular interest in Study III is the fact that while many of the cases had P. aeruginosa isolated from their ears, P. aeruginosa was not isolated from any of the swimming waters. A great effort was made to recover P. aeruginosa from the swimming pools in Study III. Up to 500 milliliters of swimming pool water was filtered and no P. aeruginosa were recovered. Among cases that swam in fresh or salt water at beaches, either P. aeruginosa was isolated from the water but not from the ear or was isolated from the ear but not from the water. Based on these limited findings, routine monitoring for P. aeruginosa or even using P. aeruginosa as an indicator of water quality would be of no value. The above evidence does not preclude the possibility of an outbreak of otitis externa in a closed system e.g.: swimming pool. There have been reported several outbreaks of otitis externa involving swimming pools. (Seyfried and Fraser, 1975; Weingarten, 1978). In these situations, high counts of P. aeruginosa, were found in the swimming pool water and in the Weingarten report, swimming pool water disinfection was found to be poor.

Data reported by Favero (1964) showed that P. aeruginosa may be isolated from swimming pools with low levels or no measurable residual chlorine. Such low residual chlorine levels also allow the growth of other potential pathogens, i.e. S. aureus. It has been recommended that swimming pool water quality be evaluated daily by chemical tests for disinfection with occasional total plate counts to check the disinfection action of the chemicals employed. (Mood, 1977).

Etiological Agents: In Study II, P. aeruginosa was the most frequently isolated organism from cases of otitis externa. (See Table 14). This is similar to the results reported by Seyfried and Fraser (1975) and Hoadley and Knight (1976). However, their studies made no effort to evaluate other organisms or to consider mixed infections. P. aeruginosa isolated from cases in Study III was found usually in a mixed infection and often was not the predominant organism present. In comparing, cases and controls, more Gram-negative bacteria were isolated from cases than from controls. This, in part, may be related to the length of time spent swimming. A study by Wright and Alexander (1974) showed that the longer the period of time during which ears are exposed to water the greater the degree of change in ear flora from initially Gram-positive bacteria to subsequently Gram-negative bacteria. The mechanism involved in such a change has not been investigated further.

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The data from Study I and Study II showed that a great many other

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Gram-negative bacteria readily colonize the outer ear canal. In Study II, Acinetobacter was the most frequently isolated Gram-negative bacteria. The potential of this organism to cause outer ear infections has been recognized as minimal (Dadswell, 1976; Griffen, 1965). Recently, this organism has become an important nosocomial pathogen (Henriksen, 1976). Acinetobacter was implicated in some cases of otitis externa in Study III. The other Gram-negative bacteria implicated were mainly enteric bacteria (Klebsiella, Enterobacter, and E. coli). This emphasizes the importance of keeping fingers and other objects out of ears. In addition, some cases demonstrated that Staphylococcus, a normal organism of the outer ear canal, was the only isolate from infected ears. The role of these organisms, apart from P. aeruginosa, should not be over looked when studying an outbreak of otitis externa.

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**Table 1.** Number of subjects at each camp session and the age, race, and socioeconomic status of those subjects. Salmen Reservation, Mississippi. June 1979.

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|                       | Frequency        | Percentage |
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| <u>Session Number</u> |                  |            |
| 1                     | 137              | 31         |
| 2                     | 162              | 36         |
| 3                     | 145              | 33         |
| Total                 | 444              | 100        |
| <u>Age (years)</u>    |                  |            |
| 10                    | 29               | 7          |
| 11                    | 94               | 21         |
| 12                    | 109              | 25         |
| 13                    | 76               | 17         |
| 14                    | 73               | 17         |
| 15                    | 21               | 5          |
| 16                    | 13               | 3          |
| 17                    | 5                | 1          |
| 18                    | 19               | 4          |
| Total                 | 439 <sup>a</sup> | 100        |
| <u>Race</u>           |                  |            |
| Caucasian             | 404              | 97.3       |
| Black                 | 5                | 1.2        |
| Latin-American        | 1                | 0.3        |
| Other                 | 5                | 1.2        |
| Total                 | 415 <sup>a</sup> | 100        |
| <u>SES</u>            |                  |            |
| Upper                 | 137              | 31         |
| Middle                | 162              | 36         |
| Lower                 | 145              | 33         |
| Total                 | 444 <sup>a</sup> | 100        |

a) Total not 444 due to incomplete questionnaires

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Table 2. Result of initial external ear canal cultures by final external ear canal cultures in campers. Salmen Reservation, Mississippi. June 1979.

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| Initial<br>Cultures    | FINAL CULTURES      |                        |                       |       |
|------------------------|---------------------|------------------------|-----------------------|-------|
|                        | Normal <sup>a</sup> | No Growth <sup>b</sup> | Abnormal <sup>c</sup> | Total |
| Normal <sup>a</sup>    | 65                  | 18                     | 86                    | 169   |
| No Growth <sup>b</sup> | 23                  | 17                     | 75                    | 120   |
| Abnormal <sup>c</sup>  | 54                  | 18                     | 82                    | 154   |
| Total                  | 147                 | 53                     | 243                   | 443   |

- a) Subject was categorized as normal if organisms isolated were the following: alpha-hemolytic streptocci, Corynebacteria, Micrococcus, Staphylococcus not Staphylococcus aureus.
- b) No organisms were isolated from either ear.
- c) An organism not classified as normal was isolated from one ear or both.

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Table 3. Frequency of abnormal isolates from external ear canal cultures by camp session. Salmen Reservation, Mississippi. June 1979.

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| Organism                          | Session 1       | Session 2 | Session 3 | Total           |
|-----------------------------------|-----------------|-----------|-----------|-----------------|
| <u>Enterobacter</u> <sup>a</sup>  |                 |           |           |                 |
| Initial                           | 9               | 4         | 6*        | 19              |
| Final                             | 3               | 6         | 17        | 26              |
| <u>Acinetobacter</u> <sup>b</sup> |                 |           |           |                 |
| Initial                           | 12              | 28*       | 28*       | 60              |
| Final                             | 22              | 58        | 55        | 135             |
| <u>Klebsiella</u> <sup>c</sup>    |                 |           |           |                 |
| Initial                           | 1               | 0         | 2         | 3               |
| Final                             | 0               | 1         | 3         | 4               |
| <u>Serratia</u> <sup>d</sup>      |                 |           |           |                 |
| Initial                           | 0               | 0         | 0         | 0               |
| Final                             | 0               | 1         | 7         | 8               |
| <u>P. aeruginosa</u>              |                 |           |           |                 |
| Initial                           | 1               | 3         | 1         | 5               |
| Final                             | 3               | 6         | 3         | 12              |
| <u>Pseudomonas</u> <sup>e</sup>   |                 |           |           |                 |
| Initial                           | 1               | 5         | 0         | 6               |
| Final                             | 4               | 6         | 9         | 15              |
| <u>Bacillus</u>                   |                 |           |           |                 |
| Initial                           | 12*             | 14        | 11*       | 37*             |
| Final                             | 20              | 25        | 26        | 71              |
| <u>S. aureus</u>                  |                 |           |           |                 |
| Initial                           | 21 <sup>#</sup> | 0         | 4         | 25 <sup>#</sup> |
| Final                             | 4               | 2         | 3         | 9               |
| <u>Miscellaneous</u> <sup>f</sup> |                 |           |           |                 |
| Initial                           | 5               | 2         | 5         | 12              |
| Final                             | 3               | 3         | 0         | 6               |

a) E. agglomeran, E. cloacae, E. aerogenes and C. freundii.

b) A. anitratus and A. lwoffii

c) K. pneumoniae, K. ozonaea and K. oxytoca

d) S. rubidaea, S. liquefaciens and S. marcescens.

e) P. fluorescens, P. stutzeri, P. paucimobilis and unspciated.

f) Moraxella, Alcaligenes and CDC group VE-1 and VE-2.

\*) Significantly more isolates ( $p < .05$ ) in final cultures by McNemar's test.

#) Significantly more isolates ( $p < .05$ ) in initial cultures by McNemar's test.

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Table 4. Camp session water quality data, air temperature and relative humidity. Salmen Reservation, Mississippi. June 1979

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| DATE <sup>d</sup> | COUNTS<br>mTEC <sup>a</sup> | PER. 100ml<br>mPA <sup>b</sup> | mE <sup>c</sup> | Temperature<br>(°F) | Humidity<br>(%) |
|-------------------|-----------------------------|--------------------------------|-----------------|---------------------|-----------------|
| 6/11              | 9.33                        | 9.1                            | 0               | 81                  | 38              |
| 6/12              | 4.0                         | 0                              | .66             | 85                  | 38              |
| 6/13              | 6.0                         | .66                            | 1.5             | 85                  | 38              |
| 6/14              | 3.7                         | 2.0                            | .66             | 36                  | 39              |
| 6/18              | 9.0                         | 2.0                            | 1.0             | 92                  | 37              |
| 6/19              | 0                           | 34.4                           | 5.0             | 93                  | 31              |
| 6/20              | 8                           | 14.0                           | 10.0            | 94                  | 36              |
| 6/21              | 6.0                         | 3.5                            | 7.0             | 88                  | 46              |
| 6/25              | 5.0                         | 6.5                            | 10.0            | 88                  | 55              |
| 6/26              | 9.0                         | 1.0                            | 3.5             | 89                  | 44              |
| 6/27              | 0.0                         | 2.0                            | 6.5             | 88                  | 40              |
| 6/28              | 110.0                       | 0.0                            | 5.0             | 90                  | 36              |

- a) Selective medium for Escherichia coli.  
 b) Selective medium for Pseudomonas aeruginosa.  
 c) Selective medium for enterocci.  
 d) Session 1 = 6/11 - 6/14, Session 2 = 6/18 - 1/21, Session 3 = 6/25 - 6/28.

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Table 5. Number of subjects at each camp session and the age, race and socioeconomic status of those subjects. Camp Salmen, Louisiana, July 1979.

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| Variable           | Frequency        | Percentage |
|--------------------|------------------|------------|
| <u>Session</u>     |                  |            |
| 5                  | 147              | 35         |
| 6                  | 141              | 33         |
| 7                  | 138              | 32         |
| Total              | 426              | 100        |
| <u>Age (years)</u> |                  |            |
| 9                  | 1                | 0.2        |
| 10                 | 11               | 2.6        |
| 11                 | 83               | 19.5       |
| 12                 | 93               | 21.9       |
| 13                 | 94               | 22.1       |
| 14                 | 66               | 15.5       |
| 15                 | 31               | 7.2        |
| 16                 | 17               | 4.0        |
| 17                 | 5                | 1.2        |
| 18                 | 24               | 5.6        |
| Total              | 425 <sup>a</sup> | 100.0      |
| <u>Race</u>        |                  |            |
| Caucasian          | 330              | 81.9       |
| Black              | 64               | 15.9       |
| Latin-American     | 2                | 0.5        |
| Other              | 7                | 1.7        |
| Total              | 403 <sup>a</sup> | 100.0      |
| <u>SES</u>         |                  |            |
| Upper              | 276              | 65         |
| Middle             | 98               | 23         |
| Lower              | 50               | 12         |
| Total              | 424 <sup>a</sup> | 100        |

a) Total not 426 due to incomplete questionnaires.

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Table 6. Results of initial external ear cultures by final external ear cultures in campers. Camp Salmen, Louisiana. July 1979.

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| Initial Cultures       | FINAL CULTURES |           |          |       |
|------------------------|----------------|-----------|----------|-------|
|                        | Normal         | No Growth | Abnormal | Total |
| Normal <sup>a</sup>    | 30             | 0         | 178      | 208   |
| No Growth <sup>b</sup> | 7              | 1         | 40       | 48    |
| Abnormal <sup>c</sup>  | 19             | 1         | 151      | 170   |
| Total                  | 56             | 1         | 369      | 426   |

a) Isolates of alpha-hemolytic streptococci, Corynebacteria, Micrococcus and Staphylococcus not S. aureus from both ears or one ear and the other "No growth".

b) No organisms were isolated from both ears.

c) An organism not considered normal was isolated from one ear or both ears.

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Table 7. Frequency of abnormal isolates by camp session. Camp Salmen, Louisiana, July 1979.

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| Organism                          | Session 5 | Session 6 | Session 7 | Total |
|-----------------------------------|-----------|-----------|-----------|-------|
| <u>Enterobacter</u> <sup>a</sup>  |           |           |           |       |
| Enter                             | 7*        | 10*       | 13        | 30*   |
| Exit                              | 29        | 40        | 13        | 82    |
| <u>Acinetobacter</u> <sup>b</sup> |           |           |           |       |
| Enter                             | 22*       | 38*       | 13*       | 73*   |
| Exit                              | 97        | 66        | 75        | 238   |
| <u>Klebsiella</u> <sup>c</sup>    |           |           |           |       |
| Enter                             | 2         | 1         | 1         | 4     |
| Exit                              | 0         | 8         | 1         | 9     |
| <u>Serratia</u> <sup>d</sup>      |           |           |           |       |
| Enter                             | 3         | 1         | 0         | 4     |
| Exit                              | 0         | 5         | 1         | 6     |
| <u>P. aeruginosa</u> <sup>e</sup> |           |           |           |       |
| Enter                             | 6         | 4*        | 4         | 14*   |
| Exit                              | 10        | 15        | 3         | 28    |
| <u>Pseudomonas</u> <sup>e</sup>   |           |           |           |       |
| Enter                             | 10        | 4         | 4*        | 18*   |
| Exit                              | 12        | 8         | 17        | 37    |
| <u>Bacillus</u>                   |           |           |           |       |
| Enter                             | 11*       | 10*       | 21*       | 42*   |
| Exit                              | 53        | 44        | 67        | 164   |
| <u>Miscellaneous</u> <sup>f</sup> |           |           |           |       |
| Enter                             | 2         | 2         | 1         | 5     |
| Exit                              | 8         | 0         | 3         | 11    |
| <u>S. aureus</u>                  |           |           |           |       |
| Enter                             | 5         | 2         | 0         | 7     |
| Exit                              | 0         | 0         | 0         | 0     |

a) E. agglomerans, E. cloacae, E. aerogenes and C. freundii

b) A. anitratus and A. lwoffii

c) K. pneumoniae, K. ozonaea and K. oxytoca

d) S. rubidaea, S. liquefaciens and S. marcescens

e) P. fluorescens, P. stutzeri, P. paucimobilis, P. cepacia, P. maltophilia, P. putida, P. pseudomalla and unspecified.

f) Moraxella, and CDC Group VE-2.

\*) Significantly more isolates ( $p < .05$ ) in final cultures by McNemar's test.

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Table 8. Camp session water quality data, air temperature and relative humidity. Camp Salmen, Louisiana. July 1979.

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| DATE <sup>e</sup> | TEMP | HUMID             | COUNTS PER 100 ml |                 |                  |                  | CHLORINE | pH  |
|-------------------|------|-------------------|-------------------|-----------------|------------------|------------------|----------|-----|
|                   |      |                   | mTEC <sub>a</sub> | mE <sub>b</sub> | mAC <sub>c</sub> | mPA <sub>d</sub> |          |     |
| 7/16              | 92   | 62 a <sup>f</sup> | 0                 | 0               | ND               | 0                | 0.2      | 8.0 |
|                   |      | p <sup>g</sup>    | 2                 | 2               | ND               | 29               | 0        | 8.0 |
| 7/17              | 94   | 54 a              | 0                 | 0               | ND               | 0                | 0.2      | 8.0 |
|                   |      | p                 | 1                 | 3               | ND               | 20               | 0        | 8.0 |
| 7/18              | 85   | 72 a              | 0                 | 0               | ND               | 0                | 0        | 8.0 |
|                   |      | p                 | 0                 | 3.5             | ND               | 38               | 0        | 8.0 |
| 7/19              | 85   | 76 a              | NO SWIMMING       |                 |                  |                  |          |     |
|                   |      | p                 | 1                 | 0               | ND               | 0                | 0        | 8.0 |
| 7/20              | 84   | 74 p              | 0                 | 0               | ND               | 0                | 0.2      | 8.0 |
| 7/23              | 79   | 82 a              | 0                 | 0               | 0                | 0                | 2.0      | 7.8 |
|                   |      | p                 | 0                 | 0               | 0                | 0                | 0        | 8.0 |
| 7/24              | 87   | 75 a              | 0                 | 11              | TNTC             | TNTC             | 0        | 7.8 |
|                   |      | p                 | 0                 | 15              | 18000            | 245              | 0        | 7.8 |
| 7/25              | 89   | 75 a              | 0                 | 0               | 0                | 0                | 0.4      | 7.8 |
|                   |      | p                 | 0                 | 3.5             | 177              | 275              | 0        | 7.8 |
| 7/26              | 88   | 70 a              | 0                 | 0               | 0                | 0                | 0        | 7.8 |
|                   |      | p                 | 3                 | 1               | ND               | 38               | 0        | 7.8 |
| 7/27              | 91   | 64 a              | NO SWIMMING       |                 |                  |                  |          |     |
|                   |      | p                 | 0                 | 0               | 0                | 8.5              | 0        | 7.8 |
| 7/28              | 90   | 70 p              | 0                 | 6.5             | TNTC             | 0                | 0        | 7.8 |
| 7/30              | 90   | 64 a              | 0                 | 0               | 21               | 0                | 0.4      | 8.0 |
|                   |      | p                 | 1                 | 1               | TNTC             | 0                | 0        | 8.0 |
| 7/31              | 90   | 64 a              | 0                 | 0               | 0                | 0                | 0        | 8.0 |
|                   |      | p                 | 0                 | 1               | 150              | 7                | 0        | 8.0 |
| 8/1               | 92   | 62 a              | 0                 | 0               | 0                | 0                | 0.6      | 8.0 |
|                   |      | p                 | 7                 | 0               | 60000            | 0                | 0        | 8.0 |
| 8/2               | 91   | 60 a              | 0                 | 0               | 25               | 0                | 0.1      | 7.7 |
|                   |      | p                 | 0                 | 3.5             | 47000            | 59               | 0        | 7.9 |
| 8/3               | 89   | 64 a              | NO SWIMMING       |                 |                  |                  |          |     |
|                   |      | p                 | 1                 | ND              | ND               | ND               | 0.1      | 8.0 |

a) Selective medium for Escherichia coli.

b) Selective medium for enterococci.

c) Experimental selective for Acinetobacter.

d) Selective medium for Pseudomonas aeruginosa.

e) 7/16-7/20 = Session 5, 7/23-2/28 = Session 6, 7/30-8/3 = Session 7.

f) Morning sample.

g) Afternoon sample.

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Table 9. Comparison of camp sessions average relative humidity, average air temperature, average Escherichia coli, enterococci and Pseudomonas aeruginosa counts between Salmen Reservation and Camp Salmen, New Orleans, Louisiana. June-July, 1979.

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| Variable                                         | Salmen Reservation<br>Lake | Camp Salmen<br>Swimming Pool |
|--------------------------------------------------|----------------------------|------------------------------|
| Average humidity                                 |                            |                              |
| week 1                                           | 38.2 <sup>b</sup>          | 67.6                         |
| week 2                                           | 37.5                       | 72.7                         |
| week 3                                           | 43.8                       | 62.8                         |
| Average air temperature                          |                            |                              |
| week 1                                           | 84.2 <sup>c</sup>          | 88.0                         |
| week 2                                           | 91.8                       | 87.3                         |
| week 3                                           | 88.8                       | 90.4                         |
| Average <u>E. coli</u> counts <sup>a</sup>       |                            |                              |
| week 1                                           | 5.8                        | 0.5                          |
| week 2                                           | 5.8                        | 0.3                          |
| week 3                                           | 31.0                       | 1.0                          |
| Average enterococci counts <sup>a</sup>          |                            |                              |
| week 1                                           | 0.7                        | 0.9                          |
| week 2                                           | 5.8                        | 3.6                          |
| week 3                                           | 6.2                        | 0.7                          |
| Average <u>P. aeruginosa</u> counts <sup>a</sup> |                            |                              |
| week 1                                           | 2.9                        | 10.9                         |
| week 2                                           | 13.5                       | 62.9                         |
| week 3                                           | 2.4                        | 8.2                          |

a) counts per 100 ml  
b) in %  
c) of

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Table 10. Clinical signs or symptoms of otitis externa cases treated at Yale Health Plan. July-September, 1980.

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| <u>Symptoms</u>               | <u>%</u> | <u>N</u> |
|-------------------------------|----------|----------|
| <u>Pain</u>                   | 96.6     | 28       |
| <u>Fever</u>                  | 3.4      | 1        |
| <u>Swelling</u>               | 55.1     | 16       |
| <u>Exudate</u>                |          |          |
| None                          | 17.2     | 5        |
| Moderate                      | 72.4     | 21       |
| Heavy                         | 10.3     | 3        |
| <u>Color of Exudate</u>       |          |          |
| White-yellow                  | 16.7     | 4        |
| white                         | 33.3     | 10       |
| yellow                        | 33.3     | 10       |
| brown                         | 4.2      | 1        |
| clear                         | 8.3      | 2        |
| green                         | 4.2      | 1        |
| <u>Consistency of Exudate</u> |          |          |
| Thin                          | 24.0     | 7        |
| Medium                        | 56.0     | 16       |
| Thick                         | 20.0     | 6        |
| <u>Evidence of Trauma</u>     | 6.9      | 2        |
| <u>Condition of Ear Wax</u>   |          |          |
| Absent                        | 42.3     | 12       |
| Normal                        | 50.0     | 14       |
| Heavy                         | 7.7      | 2        |
| <u>Severity of Infection</u>  |          |          |
| Moderate                      | 92.9     | 26       |
| Severe                        | 7.1      | 2        |
| <u>Infection in:</u>          |          |          |
| Left Ear                      | 20.7     | 6        |
| Right Ear                     | 41.4     | 12       |
| Both Ears                     | 37.9     | 11       |

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Table 11. Exposure due to swimming by cases of otitis externa and controls. Yale Health Plan. July-September, 1980.

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| Swimming | Cases | Controls | Totals |
|----------|-------|----------|--------|
| Yes      | 29    | 18       | 47     |
| No       | 0     | 11       | 11     |
| Total    | 29    | 29       | 58     |

Chi-square Value= 13.574  
DF = 1  
Probability=0.0002

Table 12. Average hours a week of swimming by cases and controls. Yale Health Plan. July-September, 1980.

| Average Hours | Cases | Controls | Total |
|---------------|-------|----------|-------|
| 4 or more     | 24    | 9        | 33    |
| Less than 4   | 5     | 9        | 14    |
| Total         | 29    | 18       | 47    |

Chi-square value = 5.699  
Degrees of Freedom = 1  
Probability= 0.007

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Table 13. Types of recreational water used by otitis externa cases and controls. Yale Health Plan. July-September, 1980.

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| Recreational<br>Water | Cases<br>N (%) | Controls<br>N (%) | Total |
|-----------------------|----------------|-------------------|-------|
| Fresh water           | 2 (7)          | 2 (11)            | 4     |
| Salt water            | 1 (3)          | 1 (6)             | 2     |
| Pool water            | 23 (80)        | 14 (77)           | 37    |
| Fresh and Pool        | 2 (7)          | 0                 | 2     |
| Salt and Pool         | 1 (3)          | 1 (6)             | 2     |
| Total                 | 29 (100)       | 18 (100)          | 47    |

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Table 14. The median and range of environmental factors and bacterial indicators of water quality for cases and controls. Yale Health Plan, 1980.

| Variable                                   | Cases  |                       | Controls |          |
|--------------------------------------------|--------|-----------------------|----------|----------|
|                                            | Median | Range                 | Median   | Range    |
| Water Temperature*                         | 80°F   | 74-85°F <sup>T</sup>  | 76°F     | 62-81°F  |
| Water pH                                   | 7.2    | 6.6-7.6 <sup>T</sup>  | 7.1      | 6.5-8.0  |
| Relative Humidity (%)                      | 57     | 40-86                 | 66       | 40-80    |
| Fecal Coliforms <sup>a</sup>               | 0      | 0.475 <sup>R</sup>    | 0        | 0-55     |
| Enterococci <sup>a</sup>                   | 1      | 0.23 <sup>R</sup>     | 0        | 0-14     |
| <u>Pseudomonas aeruginosa</u> <sup>a</sup> | 0      | 0-1.5 <sup>R</sup>    | 0        | 0.37-8   |
| <u>Staphylococcus</u> <sup>ad</sup>        | 400    | 102-2055 <sup>T</sup> | 475      | 60-6767  |
| Total Plate <sup>bd</sup> Counts           | 25     | 3-2150                | 54       | 1-1525   |
| Free Residual <sup>c</sup> Chlorine        | .30    | .01-2.00              | .70      | .03-1.20 |
| Total Residual <sup>c</sup> Chlorine       | .48    | .02-2.35              | 1.00     | .15-2.00 |

a) Average counts per 100 millileters

b) Average counts per 1 millileter

c) In parts per million

d) Assessed in swimming pools only

\* Cases were significantly higher than controls at  $p < .05$

T) Significant differences between cases and controls tested using a students t- test

R) Significant differences between cases and controls tested using a rank sum test

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Table 15. Frequency of microbiological isolates in otitis externa cases and controls ear cultures. Yale Health Plan, 1980.

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| Organisms                      | Cases <sup>a</sup> | Controls <sup>b</sup> |
|--------------------------------|--------------------|-----------------------|
| No growth                      | 1                  | 3                     |
| Normal Flora <sup>c</sup>      | 44                 | 50                    |
| <u>Bacillus</u> species        | 6                  | 6                     |
| <u>Streptococcus</u> - alpha   | 1                  | 2                     |
| <u>Streptococcus pneumonia</u> | 1                  | 0                     |
| <u>Staphylococcus aureus</u>   | 6                  | 5                     |
| <u>Enterococcus</u>            | 1                  | 0                     |
| <u>Acinetobacter</u> species   | 4                  | 0                     |
| <u>Enterobacter</u> species    | 3                  | 0                     |
| <u>Escherichia coli</u>        | 1                  | 0                     |
| <u>Klebsiella</u> species      | 2                  | 0                     |
| <u>Serratia marcesans</u>      | 1                  | 0                     |
| <u>Pseudomonas aeruginosa</u>  | 27                 | 0                     |
| <u>Pseudomonas maltophilia</u> | 1                  | 0                     |
| <u>Pseudomonas stutzeri</u>    | 0                  | 1                     |
| <u>Clostridium</u> species     | 1                  | 0                     |
| Yeast                          | 1                  | 2                     |

a = From 54 cultures

b = From 58 cultures

c = Normal flora was Staphylococcus epidermis, Corynebacteria and Micrococcus

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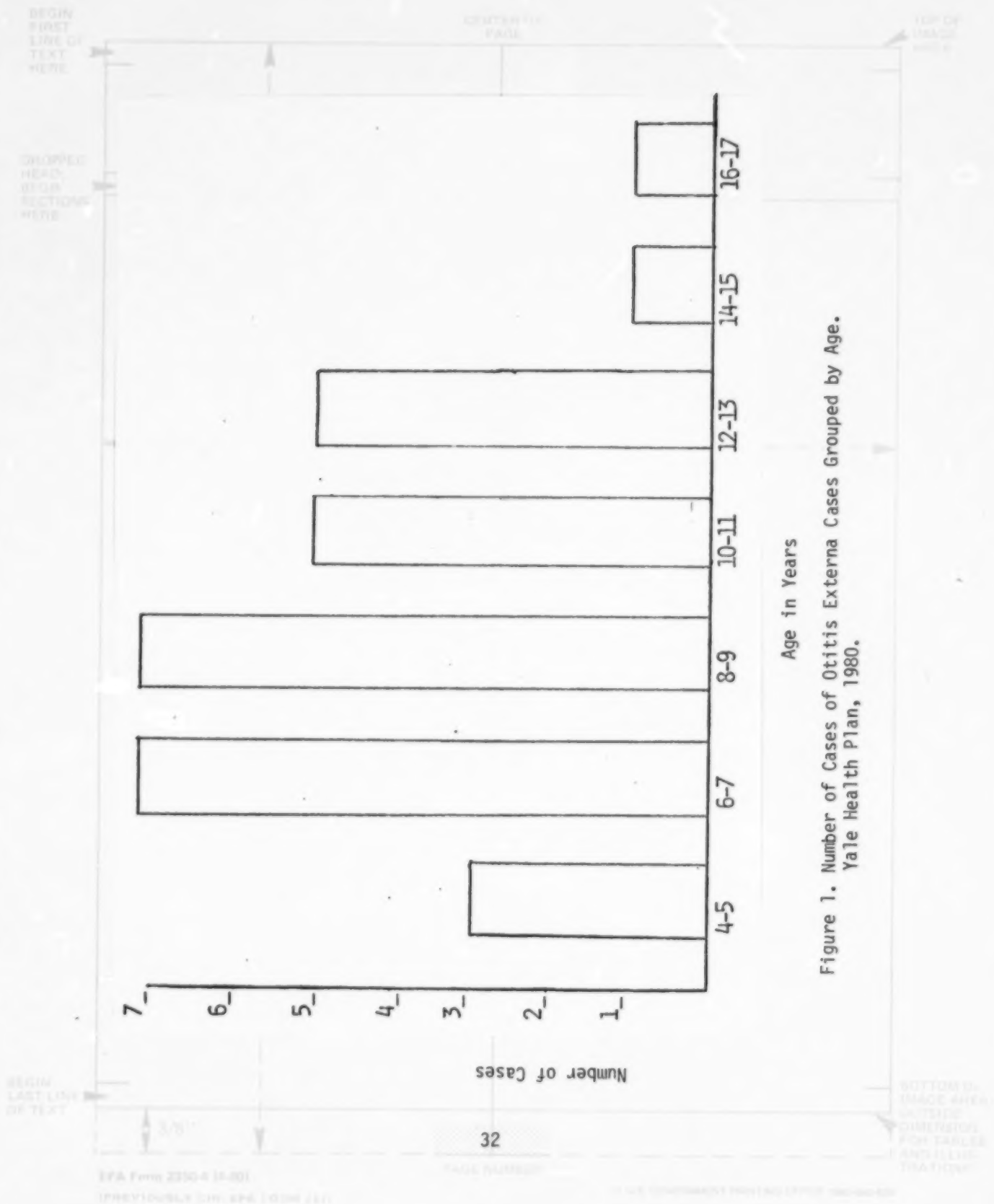


Figure 1. Number of Cases of Otitis Externa Cases Grouped by Age.  
Yale Health Plan, 1980.

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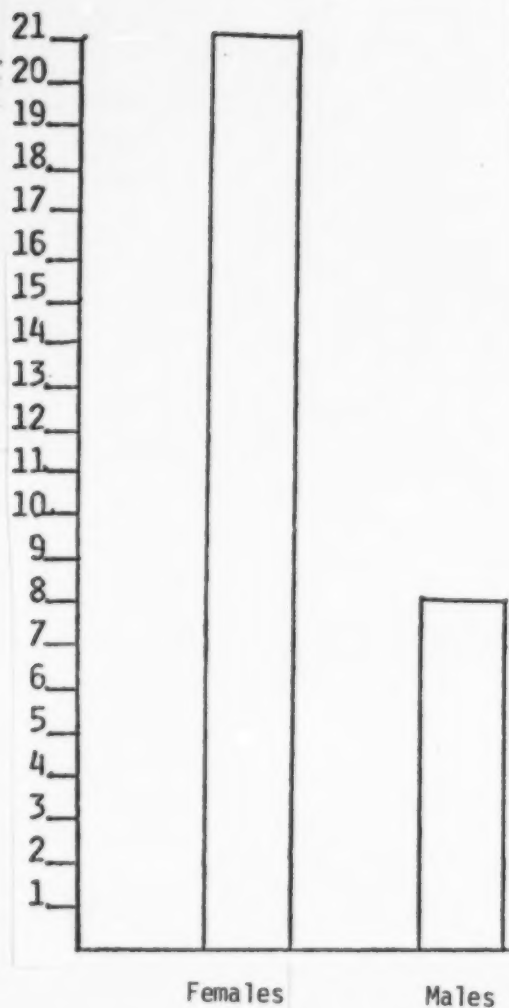


Figure 2. Number of Otitis Externa Cases by Sex.  
Yale Health Plan, 1980

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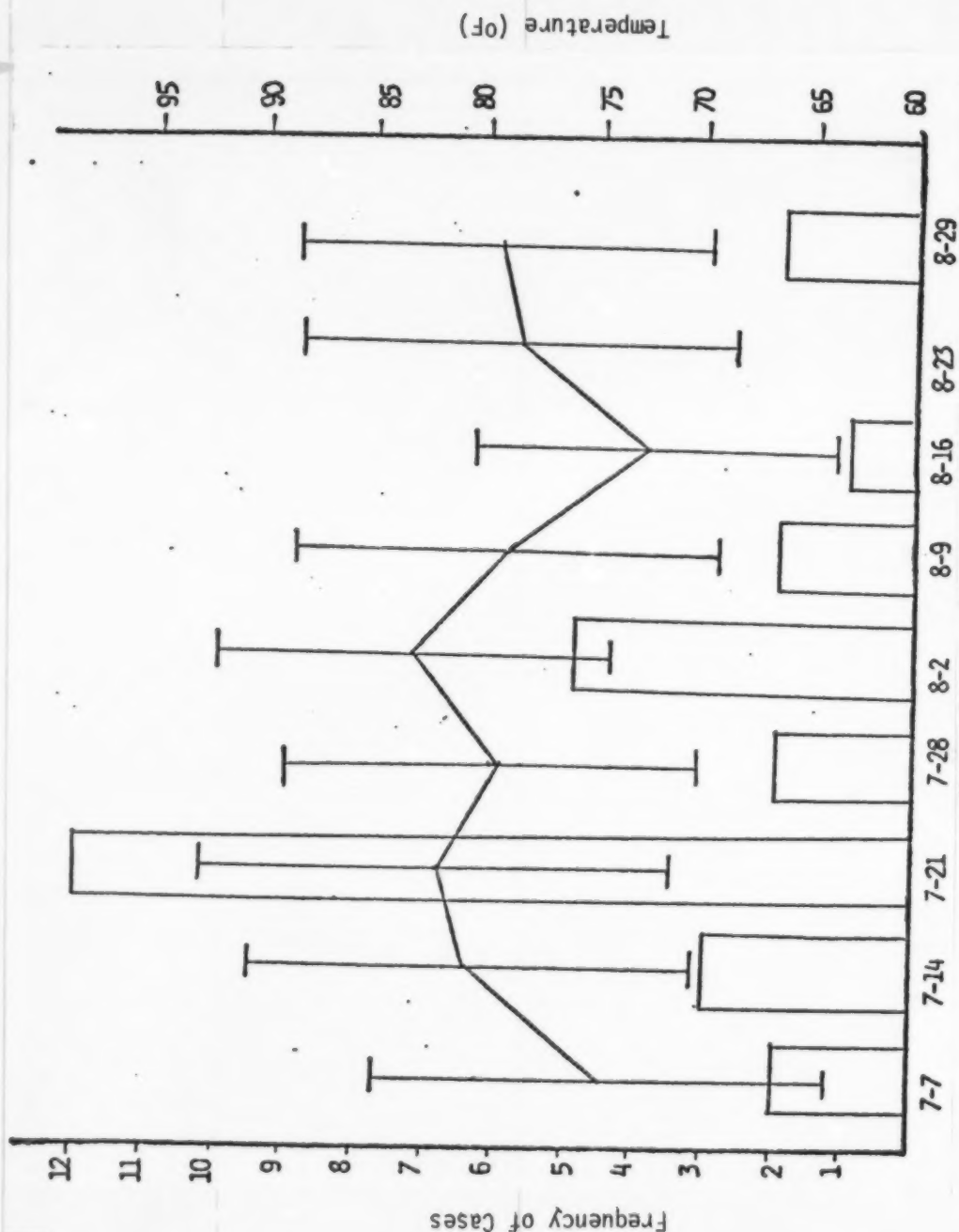


Figure 3. Frequency of Otitis Externa Cases by Week With The Average Daily Temperature Range. Yale Health Plan, 1980.

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## APPENDIX A

Troop Number: \_\_\_\_\_

Sample No.: \_\_\_\_\_

Campe Session: \_\_\_\_\_

Name: \_\_\_\_\_  
First Middle Last

Age: \_\_\_\_\_

Ethnic Background: 1 - Caucasian  
2 - Black  
3 - Latin-American  
4 - Other

Last week, did child have an earache? Yes No

If yes, was it due to a cold? Yes No

Does child have chronic earaches (>2/yr)? Yes No

If yes, are they due to a cold? Yes No

Do you use ear plugs? Yes No

How many people in family (including the child)? \_\_\_\_\_

How many rooms in home (excluding kitchen/bath)? \_\_\_\_\_

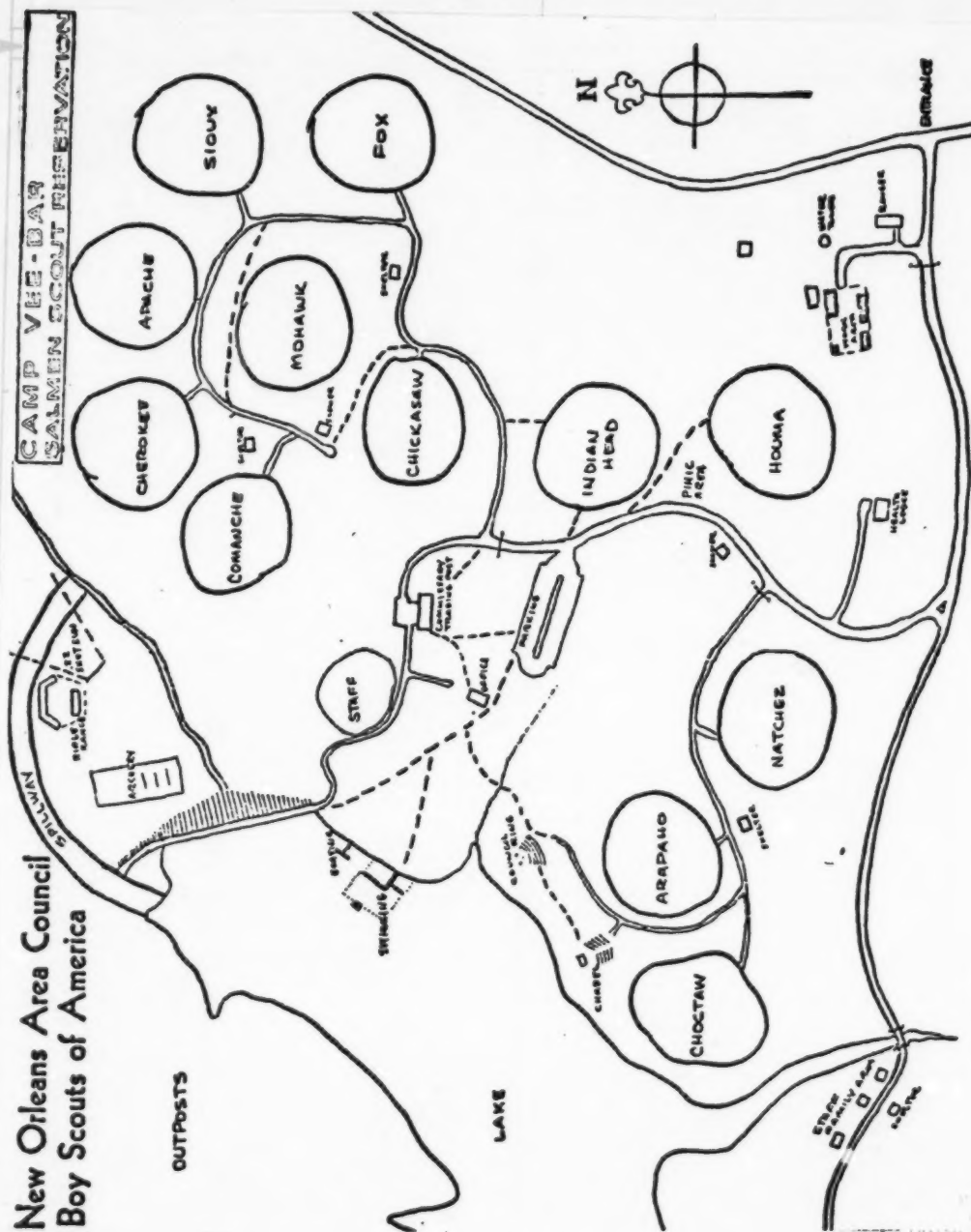
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## APPENDIX B

Name:

Address:

Phone:

Date:

### Otitis Externa Study

1. When you bathe do you (circle one)  
a) Stand in a shower b) Sit in a tub?
  2. Have you been swimming in the last seven days? Yes No  
If NO please go to question 11.
  3. How many days have you been swimming in the last week?  
1 2 3 4 5 6 7
  4. On the average what is the total amount of time spent in the water for one day?  
a) 30 minutes or less b) 30 to 60 minutes c) more than 60 minutes
  5. Where have you been swimming in the last seven days?  
Please List ALL
- | DATE | PLACE | TYPE (fresh, pool, salt) |
|------|-------|--------------------------|
|      |       |                          |
|      |       |                          |
|      |       |                          |
|      |       |                          |
|      |       |                          |
6. Do you get your face wet when you swim? Yes No
  7. Do you dive when you swim? Yes No
  8. Did you dive while swimming in the last seven days? Yes No
  9. Do you wear ear plugs when swimming? Yes No
  10. Do you wear a bathing cap when swimming? Yes No
  11. Have you had an ear infection in the last two years? Yes No  
If YES, was it associated with a cold? Yes No

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## APPENDIX B-1

Name:  
Address:  
Phone:

CONTROL  
Date:

### Otitis Externa Study

1. When you bathe do you (circle one)  
a) Stand in a shower? b) sit in a tub?
2. Have you been swimming in the last seven days? Yes No  
If NO please go to question 11.
3. How many days have you been swimming in the last week?  
1 2 3 4 5 6 7
4. On the average what is the total amount of time spent in the  
water for one day?  
a) 30 minutes or less b) 30 to 60 minutes c) more than 60 minutes
5. Where have you been swimming in the last seven days?  
Please List ALL

DATE

PLACE

TYPE (fresh, pool, salt)

6. Do you get your face wet when you swim? Yes No
7. Do you dive when you swim? Yes No
8. Did you dive while swimming in the last seven days? Yes No
9. Do you wear ear plugs when swimming? Yes No
10. Do you wear a bathing cap when swimming? Yes No
11. Have you had an ear infection in the last two years? Yes No  
If YES, was it associated with a cold? Yes No
12. Age \_\_\_\_\_ 13. \_\_\_\_\_ 14. Height \_\_\_\_\_ 15. Weight \_\_\_\_\_

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## APPENDIX B-2

### Otitis Externa Study

Date \_\_\_\_\_

1. Name \_\_\_\_\_
2. Age \_\_\_\_\_ 3. Sex \_\_\_\_\_
4. Height \_\_\_\_\_ 5. Weight \_\_\_\_\_
6. Onset of Symptoms \_\_\_\_\_

#### Patient Examination

1. Is pain present? Yes No
  2. Is fever present? Yes No
  3. Swelling:       None       Moderate       Heavy
  4. Exudate:       None       Moderate       Heavy  
Describe exudate:  
color (specify)  
consistency:   Thin       Medium       Thick
  5. Is there evidence of physical trauma due to mechanical action  
(scratching, foreign objects)?
  6. The condition of the ear wax is:   Absent       Normal       Heavy
  7. Infection in:  
a) Right Ear  
b) Left Ear  
c) Both
  8. This infection is:       Moderate       Severe
- Additional comments:

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### APPENDIX B-3

You are invited to participate in an epidemiological study concerning the nature of outer ear infections. This study is being done by the Yale School of Epidemiology and Public Health in conjunction with Yale University Health Services. The study consists of two parts. The first part collects ear cultures and information (questionnaire) from people with an ear infection. The second part collects the ear cultures and the same questionnaire information from people not experiencing an ear infection. The information gathered will be used solely for this project. Every effort will be made to keep information confidential. If you have any further questions, please ask the nurse or physician or call Rebecca Calderon at 436-8903.

AUTHORIZATION: I have read the above and agree to participate in the study.

Date

Signature

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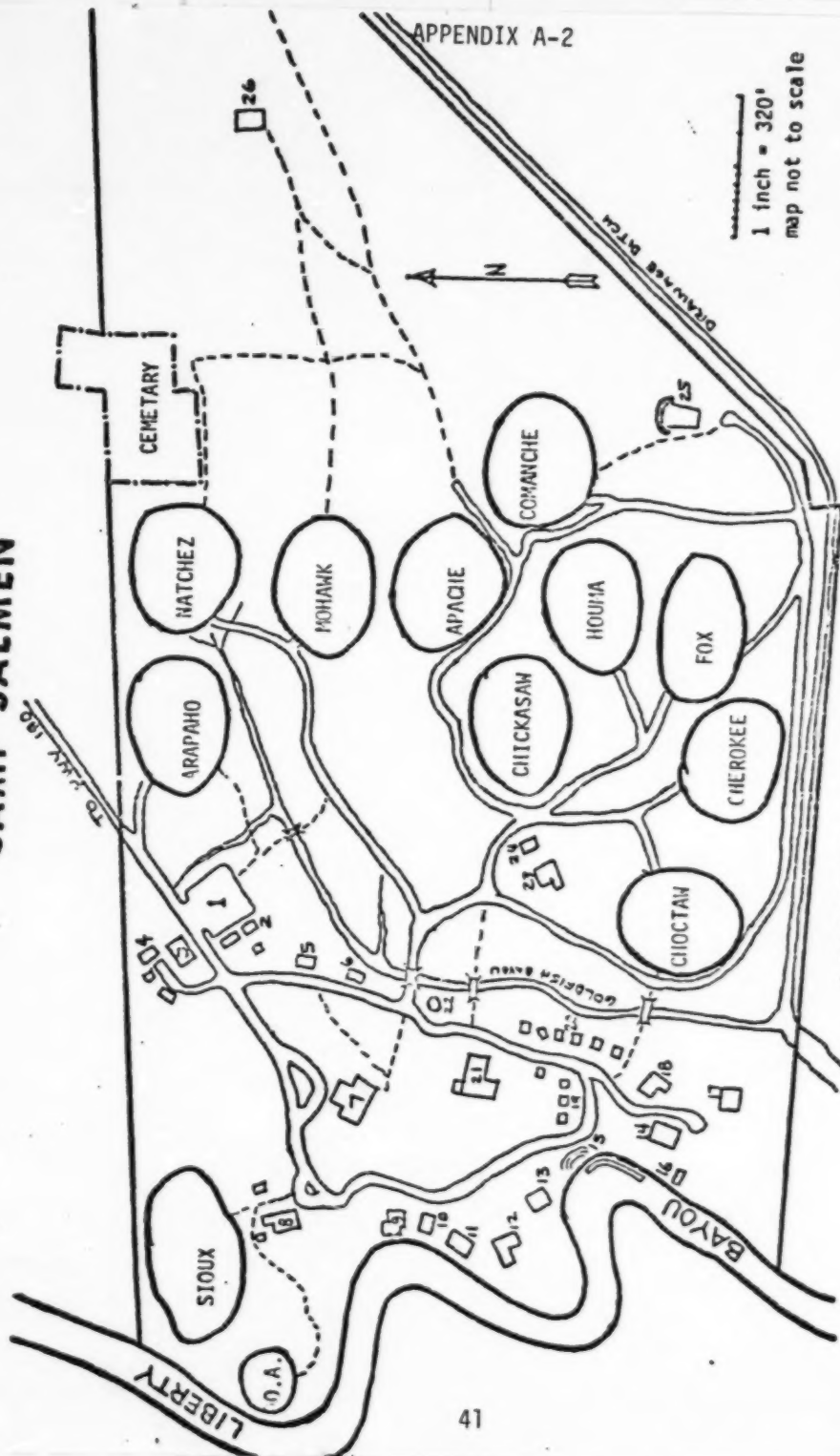
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- 6-RESTROOM
- 7-DINING HALL
- 8-QUARTERMASTER
- 9-HOSPITAL
- 10-STAFF
- 11-WORKSHOP
- 12-STAFF
- 13-STAFF
- 14-SALMEN LODGE
- 15-COUNCIL RING
- 16-BOAT HOUSE
- 17-STAFF
- 18-CHAPEL (PROT)
- 19-STAFF
- 20-STAFF
- 21-SWIMMING POOL
- 22-WATER TOWER
- 23-CHAPEL (CATH)
- 24-CRAFT LODGE
- 25-RIFLE RANGE
- 26-ARCHERY RANGE

| TECHNICAL REPORT DATA<br>(Please read instructions on the reverse before completing)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 |                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------|
| 1. REPORT NO.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2.                                                              | 3. RECIPIENT'S ACCESSION NO.<br>PB81 226196           |
| 4. TITLE AND SUBTITLE<br>Epidemiological Studies of Otitis Externa<br>Report of a prospective and of a retrospective study<br>of otitis externa among swimmers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                 | 5. REPORT DATE<br>May 1981 issuing date               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                 | 6. PERFORMING ORGANIZATION CODE                       |
| 7. AUTHOR(S)<br>Rebecca L. Calderon and Eric W. Mood                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 | 8. PERFORMING ORGANIZATION REPORT NO.                 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Department of Epidemiology and Public Health<br>Yale University School of Medicine<br>60 College Street<br>New Haven, Connecticut 06510                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                 | 10. PROGRAM ELEMENT NO.<br>A/CAQB1A                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                 | 11. CONTRACT/GRANT NO.<br>Grant 80-234                |
| 12. SPONSORING AGENCY NAME AND ADDRESS<br>Health Effects Research Laboratory<br>Office of Research and Development<br>U.S. Environmental Protection Agency<br>Cincinnati, Ohio 45268                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 | 13. TYPE OF REPORT AND PERIOD COVERED<br>Final Report |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                 | 14. SPONSORING AGENCY CODE<br>EPA/600/HERL            |
| 15. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                 |                                                       |
| 16. ABSTRACT<br><p>Two epidemiological studies of otitis externa were conducted, one was a prospective study conducted in the summer of 1979 which compared boy scouts at camp that swam in a fresh water lake with boy scouts at another camp that swam in a chlorinated swimming pool, and the other was a retrospective study conducted at Yale University during the summer of 1980. The prospective study yielded no cases of otitis externa; the retrospective study compared 29 cases with 29 controls who were matched by age and sex.</p> <p>In the prospective study a higher relative humidity at the camp where the boy scouts swam in a chlorinated pool was associated with a greater degree of abnormal flora colonization of the ear (Gram-negative bacteria and <i>S. aureus</i>). In the retrospective study, positive association was demonstrated with cases of otitis externa for ambient air temperatures, water temperature, less than 18 years of age, being female, swimming and length of time spent swimming. There was no association between cases of otitis externa and water quality as measured by fecal coliforms, enterococci and <i>P. aeruginosa</i> and between abnormal flora colonization of the ear with bacterial indices of water quality.</p> |                                                                 |                                                       |
| 17. KEY WORDS AND DOCUMENT ANALYSIS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                 |                                                       |
| a. DESCRIPTORS<br>Otitis<br>Aquatic microbiology<br>Pseudomonas<br>Coliform bacteria<br>Swimming pools                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | b. IDENTIFIERS/OPEN ENDED TERMS<br>Epidemiologic<br>evaluations | c. COSATI Field/Group                                 |
| 18. DISTRIBUTION STATEMENT<br>Release to Public                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 19. SECURITY CLASS (This Report)<br>Unclassified                | 21. NO. OF PAGES                                      |
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